2. An interface apparatus as recited in claim 1 wherein said three degrees of freedom include two degrees of freedom provided in a planar workspace and a third degree of freedom provided as rotation of said planar workspace about an axis, wherein a first and second of said actuators apply force in said planar workspace and a third of said actuators applies force about said axis.

3. An interface apparatus as recited in claim 2 wherein at least some of said plurality of members of said spatial mechanism are formed as a closed loop linkage that provides said planar workspace.

4. An interface apparatus as recited in claim 3 wherein said closed loop linkage includes five members, and wherein each of said five members of said closed loop linkage is rotatably coupled to at least two other members of said linkage, said five member linkage providing two of said three degrees of freedom.

6. An interface apparatus as recited in claim 1 wherein one of said members of said 3-D spatial mechanism is a rotatable carriage rotatably coupled to a ground member coupled to said ground, said carriage providing a third degree of freedom.

7. An interface apparatus as recited in claim 1 further comprising means for transmitting a force from one of said actuators to said spatial mechanism.

8. An interface apparatus as recited in claim 6 further comprising two capstan drive mechanisms, each coupled between one of said actuators and said closed loop linkage, wherein each of said capstan drive mechanisms includes a drum coupled to said carriage and a pulley coupled to one of said actuators, wherein a member of said linkage is coupled to said drum, and wherein said drum is coupled to said pully by a cable such that said actuator is operative to rotate said pulley and thereby transmit force to said linkage with no substantial backlash.

9. An interface apparatus as recited in claim 1 wherein said user manipulable object includes a stylus.

10. An interface apparatus as recited in claim 1 wherein said user manipulable object includes at least a portion of a medical instrument.

11. An interface apparatus as recited in claim 1 further comprising a floating gimbal mechanism coupling said one of said plurality of members to said user manipulatable object to provide rotational movement for said object in a fourth degree of freedom.

12. An interface apparatus as recited in claim 11 wherein said floating gimbal mechanism provides rotational movement for said user manipulable object in a fifth degree of freedom.

13. An interface apparatus as recited in claim 12 further comprising:

a fourth degree of freedom transducer coupled between members of said floating gimbal mechanism; and

a fifth degree of freedom transducer coupled between members of said floating gimbal mechanism.

15. An interface apparatus as recited in claim 12 wherein said user manipulable object is rotatable about a longitudinal sixth axis of said object to provide a sixth degree of freedom for said object, and further comprising a sixth degree of freedom transducer coupled between said object and said floating gimbal mechanism.

22. (amended) A method for interfacing motion of a user manipulable object with a computer system, said user manipulatable object being physically contacted by a user, said user manipulatable object being moveable in at least three degrees of freedom by use of a 3-D spatial mechanism coupled to said user manipulable object and including a plurality of members including a ground member rigidly coupled to a ground, said method comprising:

[providing a user manipulable object being physically contacted by a user;]

[providing at least three degrees of freedom to said user manipulatable object using a 3-D spatial mechanism coupled to said user manipulable object and including a plurality of members including a ground member rigidly coupled to a ground;]

applying forces in three degrees of freedom to said user manipulable object in response to electrical signals from said computer system using three actuators rigidly coupled to said ground member of said spatial mechanism, said three actuators being decoupled in force from each other such that none of said actuators can apply a force to any of said other actuators; and

detecting a position of said user manipulable object in three-dimensional space and outputting sensor signals to said computer system.

23. A method as recited in claim 22 wherein said actuators provide forces in said three degrees of freedom using tensioned cables, wherein tension in each of said cables is independent of a tension in said other cables.

24. A method as recited in claim 23 further comprising transmitting force to said linkage with no substantial backlash using two capstan drive mechanisms, each coupled between one of said first and second actuators and said plurality of members, wherein each of said capstan drive

mechanisms includes a drum coupled to one of said members and a pulley coupled to one of said actuators, wherein a member of said linkage is coupled to said drum, and wherein said drum is coupled to said pully.

25. A method as recited in claim 22 wherein said three degrees of freedom include two degrees of freedom provided in a planar workspace and a third degree of freedom provided as rotation of said planar workspace about an axis with respect to said ground member.

26. A method as recited in claim 25 wherein said two of said degrees of freedom are in a planar workspace provided by a parallel link mechanism, and a third of said degrees of freedom is provided by rotating said parallel link mechanism about an axis with respect to said ground member.

27. A mechanism for providing computer-controlled forces on a user manipulable object, the mechanism comprising:

a user manipulable object graspable by a user;

means for outputting a force in a degree of freedom of said user manipulatable object;

transmission means for transmitting force between said user manipulable object and said actuator, said transmission means including capstan drum means coupled to said user manipulable object and rotatable about a first axis and rotatable pulley means coupled to and rotatable by said means for providing a force, wherein a flexible member is coupled between said drum means and said pulley means to transmit rotational force between said drum means and said pulley means; and

carriage means for rotating said user manipulatable object with respect to said ground surface about a second axis, wherein said drum means is rotatably coupled to said carriage means, and wherein said capstan drum means and said user manipulable object may be rotated about said second axis while said means for outputting a force and said pulley means are fixed to said ground surface and do not rotate about said second axis, wherein said flexible member is twisted from said rotation about said second axis;

whereby said user manipulable object is provided with a first degree of freedom about said first axis and a second degree of freedom about said second axis.

28. A mechanism as recited in claim 27 further comprising a plurality of sensing means coupled to said mechanism, said sensing means for sensing a position of said user manipulatable object in said first and second degrees of freedom.

30. A mechanism as recited in claim 27 further comprising linkage means coupled between said user manipulatable object and said drum.

31. A mechanism as recited in claim 30 further comprising second transmission means, said second capstan transmission means including:

a second drum means coupled between said user manipulable object and said carriage means and rotatable about a third axis to allow said user manipulable object to be moved in a planar workspace having said first degree of freedom and a third degree of freedom;

second means for outputting a force coupled to said ground surface and being controllable to provide a force in said third degree of freedom of said user manipulable object; and

second pulley means coupled to said second actuator and being coupled to said second capstan drum by a second flexible member.

32. A mechanism as recited in claim 31 further comprising a third means for outputting a force coupled to said ground surface, said third means outputting a force in said second degree of freedom, wherein said three means for outputting a force are each coupled to said ground surface.

33. A mechanism as recited in claim 32 further comprising a third transmission means coupled between said carriage and said third means for outputting a force, said third transmission means including third drum means rigidly coupled to said carriage means and rotatably coupled to said ground surface, third pulley means coupled to said third means for outputting a force, and a third flexible member coupled between said third drum means and said third pulley means.

34. A mechanism as recited in claim 33 wherein said flexible members are metal cables.

35. A mechanism as recited in claim 27 wherein said user manipulable object is one of a stylus and a medical instrument.

37. A mechanism as recited in claim 30 wherein said user manipulable object is coupled to said linkage means by floating gimbal means for providing at least two additional degrees of freedom to said user manipulable object.

57. An interface apparatus as recited in claim 37 wherein said floating gimbal mechanism includes at least one capstan drive mechanism and at least one sensor, said capstan drive mechanism providing enhanced sensing resolution to said sensor.

58. An interface apparatus for interfacing the motion of a stylus with a computer system that provides simulated feel sensations to a user holding said stylus, said interface apparatus comprising:

a stylus manipulatable by a user in at least three degrees of freedom with respect to a ground surface;

three actuators rigidly coupled to said ground surface;

a mechanism that couples said stylus to said three grounded actuators, said mechanism allowing motion of said stylus in said three degrees of freedom and transmitting forces from said actuators to said stylus in said three degrees of freedom, wherein said mechanism includes a plurality of rigid members and a plurality of flexible members, wherein flex of at least one of said flexible members enables motion of said stylus with respect to said ground surface; and

at least one sensor that detects a position of said user manipulatable object in three dimensions with respect to said ground surface.

59. An interface apparatus as recited in claim 58 wherein said flex of said flexible member is an axial twist.

60. (amended) An [inteface] interface apparatus as recited in claim 59 wherein said flexible members are cables.

61. An interface apparatus as recited in claim 58 wherein a plurality of members of said mechanism form a closed loop linkage of five rigid members, said closed loop linkage being driven by two of said three grounded actuators.

62. An interface apparatus as recited in claim 58 wherein said three degrees of freedom are translational degrees of freedom.

63. An interface apparatus as recited in claim 58 wherein said mechanism further comprises means for allowing three additional degrees of freedom of said stylus, said three additonal degrees of freedom being rotational degrees of freedom, thereby allowing said stylus to be manipulated in a full six degrees of freedom with respect to said ground surface.

64. An interface apparatus as recited in claim 58 wherein two of said three actuators are oriented approximately parallel with respect to each other and said third of said three actuators is oriented approximately perpendicular to said two parallel actuators.

65. An interface apparatus as recited in claim 64 wherein said two parallel actuators drive rigid links that form a closed loop chain of five members to apply forces upon said stylus in a two dimensional plane.

66. An interface apparatus as recited in claim 65 wherein said perpendicular actuator applies forces in at least one direction outside of said plane, thereby allowing forces in three dimensional space.